12

AD

AD-E400 805

CONTRACTOR REPORT ARLCD-CR-82006

INSULATION OF NITROCELLULOSE BOILING TUBS AT RADFORD ARMY AMMUNITION PLANT

CHARLES H. JOHNSON
HERCULES INCORPORATED
RADFORD ARMY AMMUNITION PLANT
RADFORD, VA 24141

SAM M. MOY
PROJECT ENGINEER
ARRADCOM

MARCH 1982

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER
WEAPON SYSTEMS LABORATORY
DOVER, NEW JERSEY

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Contractor Report ARLCD-CR-82006	2. GOVT ACCESSION NO. AD-A114 076	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INSULATION OF NITROCELLULOSE BOILING TUBS AT RADFORD ARMY AMMUNITION PLANT		5. TYPE OF REPORT & PERIOD COVERED Final July 79 - August 81
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles H. Johnson, Hercules Incorporated Sam M. Moy, Project Engineer, ARRADCOM		8. CONTRACT OR GRANT NUMBER(s) DAAA09-77-C-4007
9. PERFORMING ORGANIZATION NAME AND ADDRESS Radford Army Ammunition Plant Hercules Incorporated Radford, VA 24141		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS MMT-5794281
11. CONTROLLING OFFICE NAME AND ADDRESS ARRADCOM, TSD STINFO Div (DRDAR-TSS) Dover, NJ 07801		12. REPORT DATE March 1982
		13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) ARRADCOM, LCWSL Energetic Systems Process Div (DRDAR-LCM-SE) Dover, NJ 07801		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

DTIC SELECTE MAY 3 1982 D

S H

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This project was accomplished as part of the U.S. Army's Manufacturing Methods and Technology Program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in production of Army materiel.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Foamglas insulation
Boiling tub
Nitrocellulose purification
Energy conservation
Automatic steam control
Propellant manufacturing
MMT-Energy conservation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The sidewall of a stainless steel nitrocellulose (NC) boiling tub was thermally insulated with a 2-inch-thick layer of Foamglas®. Evaluation of steam usage was conducted and an energy saving of 155.8 kg steam per hour per tub was realized. No adverse effects on NC properties were detected due to boiling tub insulation. The design criteria information for insulating other NC boiling tubs was established.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

CONTENTS

TABLES

FIGURES

INTRODUCTION

The purpose of this project was to select, install, and evaluate a thermal insulation system for stainless steel boiling tubs at Radford Army Ammunition Plant (RAAP) and other Army Ammunition Plants.

The boiling and poaching operations of nitrocellulose (NC) purification require a series of hot water boils requiring boiling times from 1 hour to 84 hours (figs. 1 and 2). The water/NC slurry is heated with 40 pounds of steam either by percolation or by injecting the steam into the slurry. During the time that boiling and poaching tubs are being brought to the proper temperature, and the time this temperature is maintained, heat is lost through conduction and radiation from the stainless steel sides. In view of the escalating cost of energy, it was apparent that a substantial energy savings could be effected if a safe insulating system could be designed. The design criteria for the insulation system and the economic analysis of the energy saved were necessary to make a valid assessment.

PRELIMINARY STUDY

A foam-type insulation was applied to boiling tubs at Indiana Army Ammunition Plant in the 1950s. The tops of the tubs were not insulated; therefore, splash shields were installed at the periphery of the top edge to prevent NC from collecting between the insulation and tub sides. This insulation system was unsuccessful because it did not prevent NC collection; consequently, fires occurred between the insulation and tub sides on process startup in 1969. This required that all insulation be removed from boiling tubs.

A Foamglas[1] insulation system, applied to the surfaces of large stainless steel tanks used in kraft paper manufacturing, was examined at Champion International Corporation, Canton, North Carolina. Champion solved the problem of material's collecting between the insulation and tank sides by insulating the tops of each tank to prevent the flow of material into these areas. However, the tops of the boiling tubs at RAAP could not be insulated and sealed because of the openings in the tops. To prevent the NC from getting between the tank wall and the insulation, a flange was placed at the top of the tank to extend the top out beyond the insulation.

Material Selection and Application for NC Purification

The insulating material had to meet the following criteria to be included as a candidate:

---

[1] Manufactured by Pittsburg-Corning.

1. Zero permeability per ASTM C355

2. Low thermal expansion

3. High relative compressive strength

4. Lightweight

5. Impervious to nitric and sulfuric acids

6. Noncombustible per ASTM-E-136

7. Possess thermal insulating qualities

Foamglas was the only material that met all of these requirements even though its insulating potential is less than other materials evaluated.

Particular attention was given to material selection that would prevent tank surface corrosion and provide positive tank surface contact. Also, the material should not permit NC or moisture penetration if it becomes contaminated with the slurry.

A final requirement was that the NC stability remain unaffected by the reduced energy required by this purification process.

Tank Insulation

The tank was prepared to receive the insulation by welding two flanges around the periphery of the tank at the top and bottom (fig. 3). The bottom flange served as a support for the insulation during the application, while the top flange was designed to direct any water or water/NC slurry from the tank top over the insulation. This minimized the probability of material's collecting between the tank and insulation.

The 2-inch-thick Foamglas contacts the tub surface, and a thin coat of Pittcote-300 mastic is then applied to the Foamglas. A fiberglass cloth is then laid over the entire surface as a reinforcing material, after which a second coat of Pittcote-300 mastic is applied. A 0.02-inch-thick stainless steel sheeting envelopes the entire tub side and serves as a protection against insulation damage.

Insulation was not applied to the boiling tub top which contains many appurtenances, each of which presents a sealing problem (fig. 4). The probability that NC can collect between the insulation and the top and become a fire and/or explosive hazard could not be reduced to an acceptable level.

The energy conservation sacrifice due to the elimination of the top insulation (app A) represents a maximum of 34,825 Btu/hour per tub or 28.9% of the total potential savings.

The bottom of the boiling tub was not insulated because of:

1. The obvious difficulties in applying the insulation around the dunnage

2. The relatively small area of the tub bottom not covered by dunnage and exposed for insulating

3. The problems in obtaining a satisfactory seal between the tub dunnage and insulation

4. The difficulty in visually inspecting the integrity of the seal.

Because the tubs contain a false bottom and because of the nature of the percolating action, ΔT at the bottom of the tub is less than at the sides. These features tend to minimize the heat lost through the bottom.

Steam Usage

The theoretical energy required to bring a tub up to boil and to maintain the on-boil temperature, both before and after insulation was applied, is shown in appendix B. A maximum energy saving of 116,275 Btu/hour per tub or approximately 8.187×10^{10} Btu/year at mobilization is theoretically realized with insulation.

A schematic of the equipment used to measure the steam required to bring a boiling tub to the on-boil temperature and the steam necessary to maintain this temperature is shown in figure 5. Automatic controls were required because of the difference in the steam usage between operators while maintaining on-boil temperature which made it difficult to measure and compare the amount of steam used before and after insulation. The boiling tub was instrumented to measure the amount of steam used during manual control compared with automated controls and the amount required to process NC after the tub was insulated.

The quantity of steam used in this tub was measured by an in-line orifice plate that creates a differential in-line pressure proportional to steam flow. The pressure is detected by a differential pressure transducer that activates a chart recorder.

Two recorders were used, one for steam flow between 0 and 680 kg/hr (0 lb and 1500 lb/hr), and a second one for flows between 680 kg and 3402 kg/hr (1500 lb and 7500 lb/hr). A Mercoid switch was used to switch charts at approrpriate times. The control system contained a low signal limiter that allowed the control valve to remain slightly open at all times. This was necessary for the tub to maintain a percolating action and be more effective in removing the nitrating acids from the NC.

The amount of steam required to process various types of NC in a manually controlled, uninsulated tub is given in table 1. The steam usage varied from 3.49 kg of steam per kg of NC for P-7 pulp to 8.06 kg of steam per kg of NC for BL-7 cotton. These measurements on the uninsulated, manually controlled tub gave an average steam usage of 857 kg/hr (1889 lb/hr) during the three on-boil cycles for the four types of NC.

The boiling tub was set up to use one temperature sensor port for the normal temperature measurement and the other port for the automatic temperature control system. The amount of steam used for the on-boil cycle with the single-sensor autocontrol averaged 647 kg/hr (1426 lb/hr) (test 1, table 2). This was a reduction of 210 kg/hr (463 lb/hr) over the manually controlled uninsulated tub.

Steam usage with the single sensor autocontrol and insulated tub for the on-boil cycle averaged 521 kg/hr (1148 lb/hr) (test 2, table 2). This was a reduction of 126 kg/hr (277 lb/hr) over the uninsulated tub. At times during the on-boil cycle of tests 1 and 2, the temperature of the manual sensor was different from the autocontrol sensor indicating a temperature difference from one side of the tub to the other. During manual operation, both sensors are used and the steam adjusted to keep the lowest temperature above 96°C (205°F). With the single autocontrol sensor there were times when the manual sensor indicated the on-boil temperature was less than 96°C. At other times the autocontrol sensor had the steam valve open when the manual sensor showed more than 96°C. The single sensor autocontrol was not satisfactory; therefore, an improved system was designed (fig. 5) which used two temperature sensors located on opposite sides of the tub. The outputs from these sensors are transmitted in the form of 3 to 15 psig pressure to a low signal selector which selects and relays the signals representing the lowest temperature sensor to the controller. The controller opens and closes the valve based on the magnitude of these signals. In addition, a low signal limiter allows a continuous steam flow to the tub. By this mechanism, the tub is maintained at the minimum on-boil temperature, yet maintains percolating action within the tub.

While the equipment for the newly designed autosensor was on order, the insulated tub was operated with manual controls. The amount of steam required to maintain the on-boil temperature in the insulated tub was reduced to 701 kg/hr (1545 lb/hr) (test 3, table 2). This is a reduction of 155.8 kg/hr (344 lb/hr) from the average on-boil steam usage for the four tests (table 1) in the same tub before insulation.

The dual temperature sensor automatic control equipment was received and installed on the insulated tub. Considerable adjustments were required to obtain the optimum operating parameters for these controls, but the 36.7 hours of on-boil operations (test 4, table 2) showed the steam usage could be reduced to 309 kg/hr (681 lb/hr). This represented a steam reduction of 547.8 kg/hr (1208 lb/hr) from the uninsulated, manually controlled steam rates and 392 kg/hr (864 lb/hr) steam reduction from the manually controlled insulated tub. The operation at the optimum setting was of short duration because C-line operations were shut down after this test and were not scheduled to resume in 1981. The automatic control valve would be expected to use about the same quantity of steam coming up to boil as the manually controlled valve. Some benefits would be obtained from the insulated tub coming up to boil, but the exact amount of steam saved was not measured.

Economic Analysis

The economic analysis of the savings effected by the use of the insulated tub is based on actual steam measurements at mobilization rates, calculated as follows:

Tub	Steam usage kg/hr	(lb/hr)
Without insulation	856.8	1,889
With insulation	701.0	1,545
Reduction	155.8	344

Savings at mobilization rate - 65.32 x 10^6 kg/yr (144 x 10^6 lb/hr)
Average time per cycle - 44.54 hr
Cycles per year - 4,920

Steam savings -
155.8 kg/hr x 44.54 hr/cycle x 4,920 cycles/yr = 34,141,513 kg/yr

Monetary savings using 1981 steam rate of \$4.87 per 488.8 kg -
34,141,513 kg/yr x \$4.87/488.8 kg = \$340,158/yr

The cost of insulating one boiling tub house (30 tubs) is estimated to be \$405,280 based on 1981 costs.

One line at mobilization rates has a steam savings of $\frac{\$340,158}{3} = \$113,386/\text{yr}$

Insulation payback for one line - $\frac{\$405,280}{\$113,386/\text{yr}} = 3.57$ years

The calculated steam savings, based on actual data, compare favorably with the average theoretical savings of 30,223,081 kg/yr projected in appendix B.

NC Characterization

A primary requirement of the study was that the stabilization of the NC be unaffected by a reduction in the amount of energy required to effect the purification process. Laboratory results from all NC processed through the insulated boiling tub are shown in table 3. No adverse stabilization effects were detected as a result of the reduction in energy.

CONCLUSIONS AND RECOMMENDATIONS

The composite insulation system performed as predicted in conserving energy in the boiling tub purification process. No adverse effects on NC properties were detected due to boiling tub insulation.

It is recommended that Foamglas be used on all boiling tubs insulated in the future, and Pittcote-300, fiberglass mesh, and 0.020-inch-thick stainless steel be used to apply the insulation.

Since the payback time for insulating a boiling tub is less than 4 years, it is recommended that tubs required for the present level of production be insulated.

Table 1. Normal steam consumption--manually controlled uninsulated boiling tub

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Average
Type NC	P-1 Pulp	P-1 Pulp	BL-1 Cotton	BL-1 Cotton	
Amount, kg (lb)	13,500 (30,000)	13,500 (30,000)	9,000 (20,000)	9,000 (20,000)	
Time on acid boil (hr)	40	20	40	50	
Steam consumption Up to boil, kg (lb)					
1 Neutral boil	9,423 (20,939)	8,712 (19,359)	7,898 (17,550)	8,284 (18,409)	8,579 (19,064)
2 Acid boil	9,183 (20,407)	7,765 (17,255)	7,901 (17,558)	7,410 (16,467)	8,065 (17,922)
3 Acid boil	10,818 (24,484)	7,317 (16,259)	9,287 (20,638)	7,308 (16,241)	8,733 (19,406)
On boil, kg/hr (lb/hr)					
Acid boil*	823 (1,829)	823 (1,829)	823 (1,829)	823 (1,829)	823 (1,829)
5-hour boils					
1	945 (2,101)	611 (1,358)	1,043 (2,317)	894 (1,977)	872 (1,938)
2	—	769 (1,708)	1,015 (2,256)	782 (1,738)	855 (1,901)
Average on-boil consumption					
kg/hr					856.8
lb/hr					(1,889)

* Average of 1829 lb/hr based on 15 acid-boil cycles ranging from 473 kg/hr to 1,394 kg/hr (1050 lb/hr to 3097 lb/hr).

Table 2. Steam measurements during on-boil cycle

Test		Hours measured	Steam used		Rate/hr	
			kg	lb	kg	lb
1	Single sensor autocontrol without insulation	87	56,282	124,078	647	1,426
2	Single sensor autocontrol with insu'ation	70	34,233	75,470	521	1,148
3	Manual control with insulation	79.85	55,960	123,368	701	1,545
4	Dual sensor autocontrol with insulation	36.7	11,345	25,012	309	681

Table 3. Nitrocellulose characterization[a]

Lot No.	Type NC	Nitrogen[b] (N2), (%)	Solubility[b] (%)
C-3979	BL-7	12.55	99+
	(Linters)	12.55	99+
C-3826		12.62	99+
		12.60	99+
C-3845		12.60	99
		12.63	99
C-3778		12.58	99+
		12.59	99+
C-4265		12.61	99+
		12.63	99+
C4117		12.65	99+
		12.67	99+
C4165		12.53	99+
		12.55	99+
C-3890		12.65	99+
		12.65	99+
C-4106		12.59	99+
		12.56	99+
CF-3814	P-1	13.36	
	(Pulp)	13.36	
		13.39	
CF-3834		13.43	
		14.43	
		13.42	
CF-3764		13.41	
		13.41	
		13.41	
CF-4349		13.41	
		13.41	
		13.38	
CF-4363		13.42	
		13.42	
		13.42	

Table 3. (cont)

Lot No.	Type NC	Nitrogen[b] (N2), (%)	Solubility[b] (%)
CF-4376	P-1 (Pulp)	13.42	
		13.42	
		13.43	
CF-4215		13.41	
		13.41	
CF-4233		13.46	
		13.46	
		13.46	
CF-4151		13.47	
		13.47	
		13.45	
CF-3942		13.46	
		13.46	
		13.44	
CF-3956		13.48	
		13.48	
		13.46	
CF-4082		13.42	
		13.45	
		13.42	
CF-3788	P-7 (Pulp)	12.51	99+
		12.51	99+
		12.51	99+
CF-4247		12.74	99+
		12.74	99+
		12.73	99+
CF-4280		12.65	99+
		12.65	99+
		12.62	99+
CF-4298		12.71	99+
		12.71	99+
		12.68	99+

Table 3. (cont)

Lot No.	Type NC	Nitrogen[b] (N2), (%)	Solubility[b] (%)
CF-4014	P-7 (Pulp)	12.58	99+
		12.58	99+
		12.61	99+

---

[a] Stability--30 min German test.

[b] Acceptable limits:

BL-7	12.45 to 12.75	99+
P-1	13.35 minimum	No Specification Requirement
P-7	12.45 to 12.75	99+

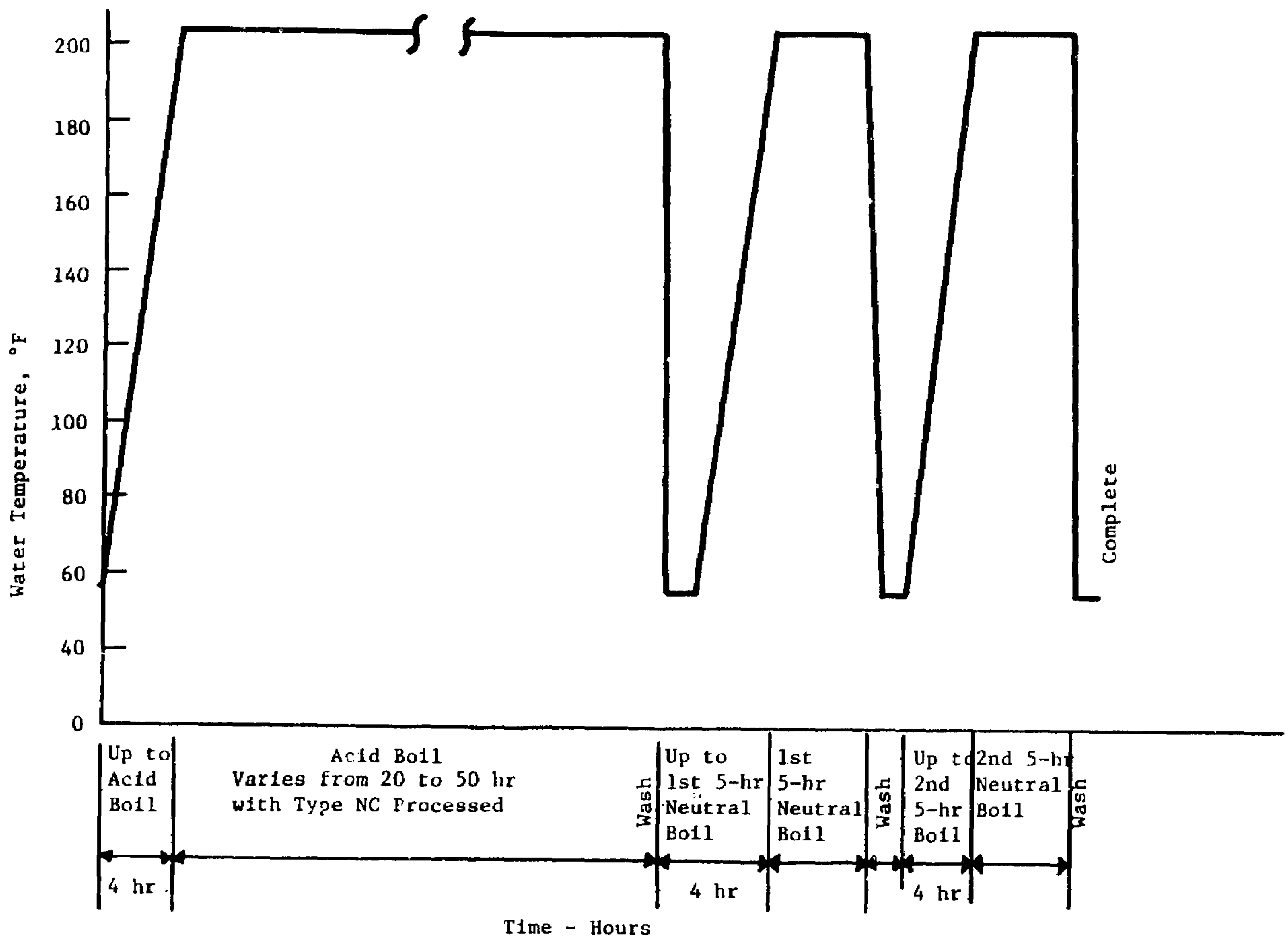

Figure 1. Typical boiling tub cycle

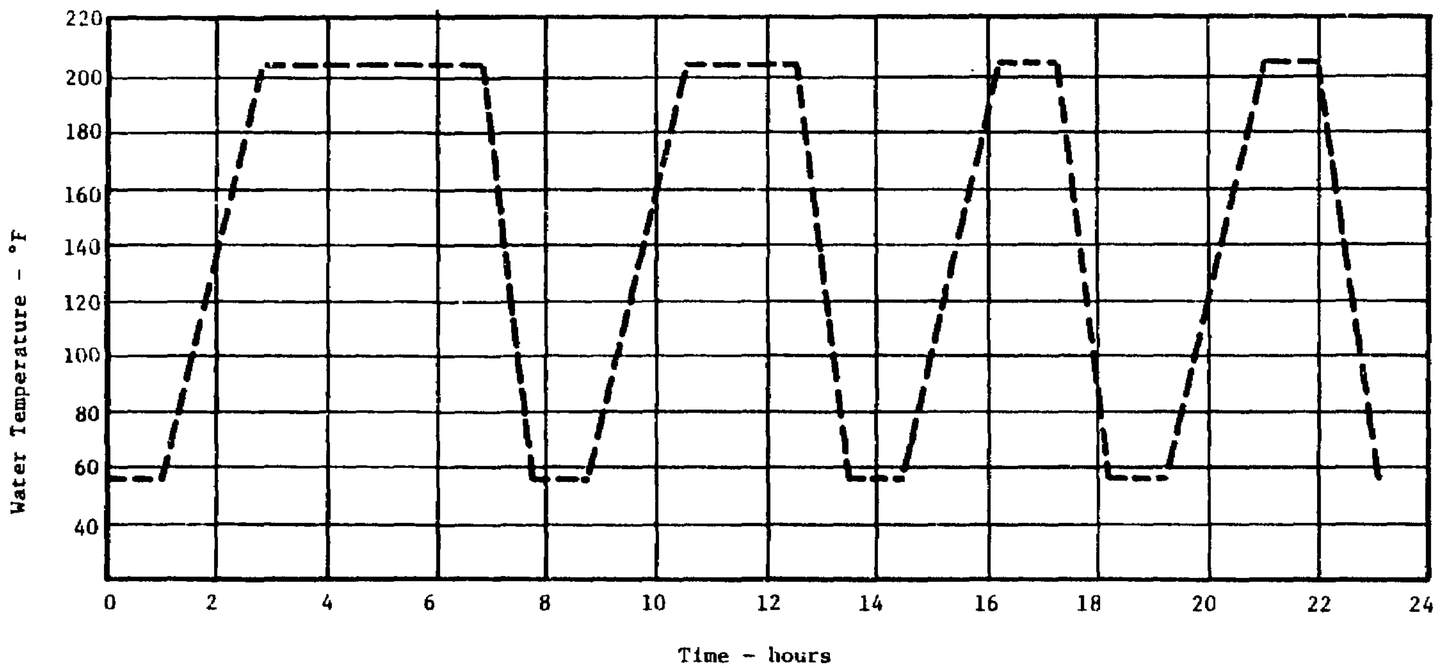

Figure 2. Idealized poacher cycle

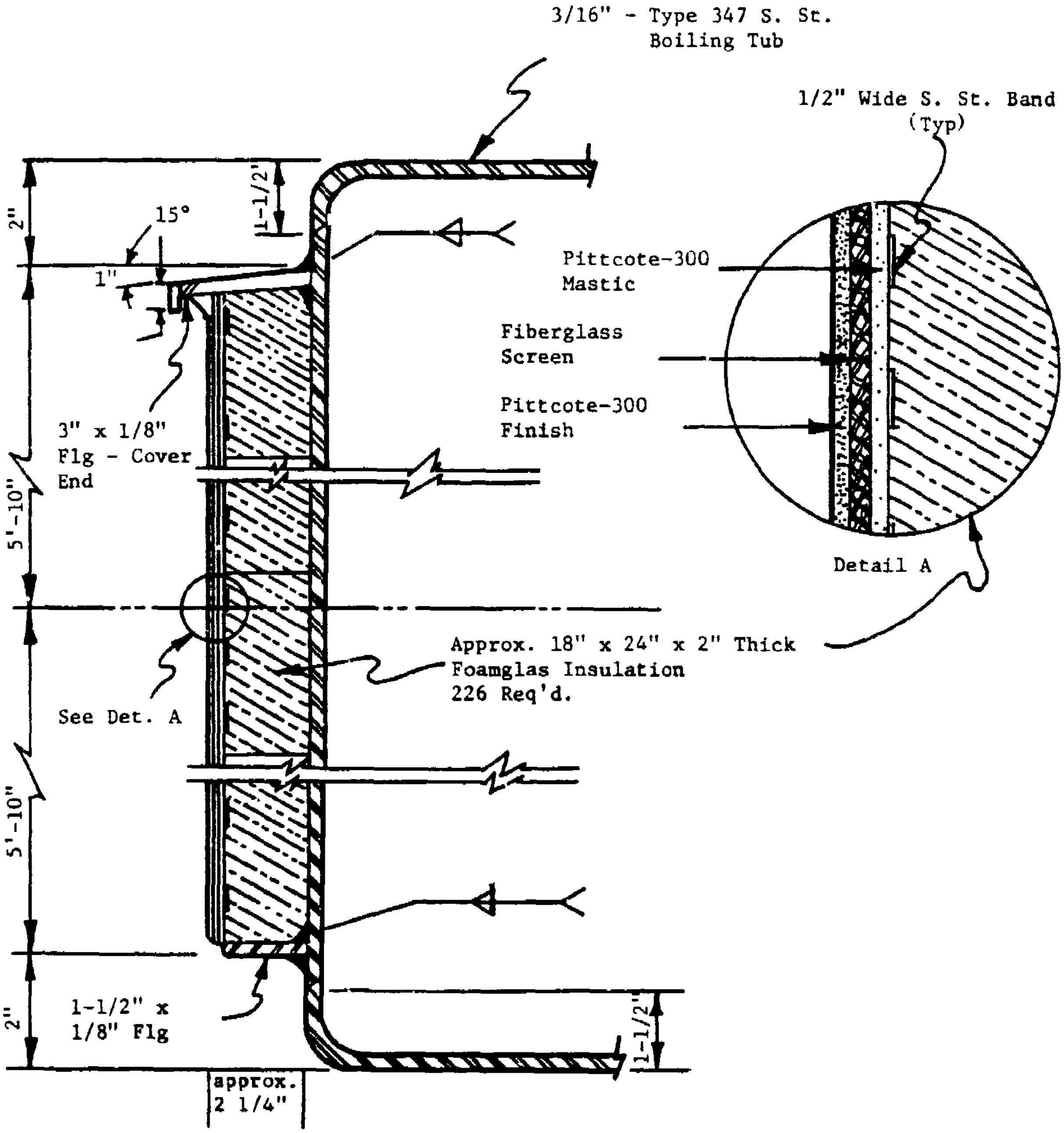

Figure 5. Boiling tub insulation details

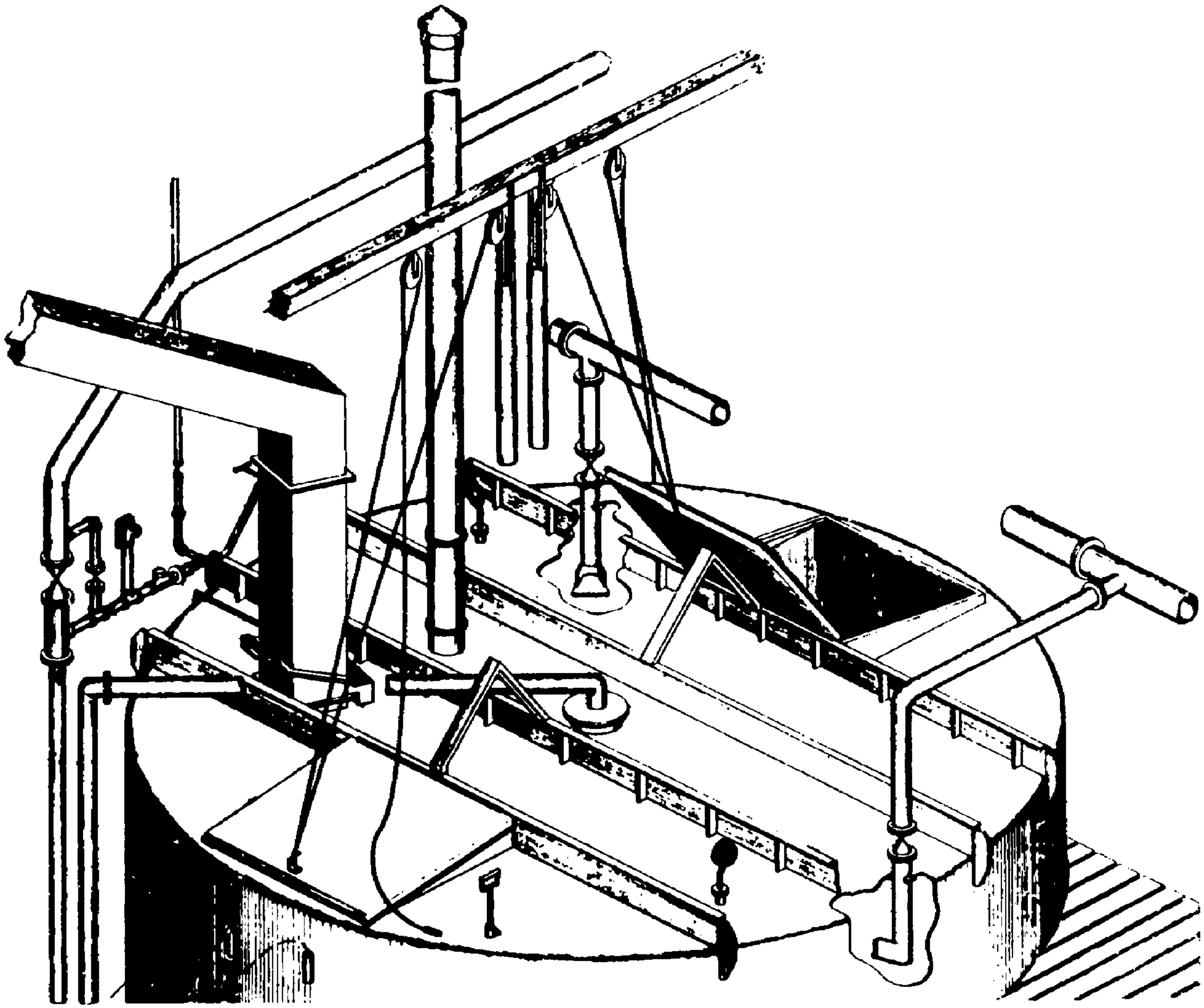

Figure 4. Top of boiling tub

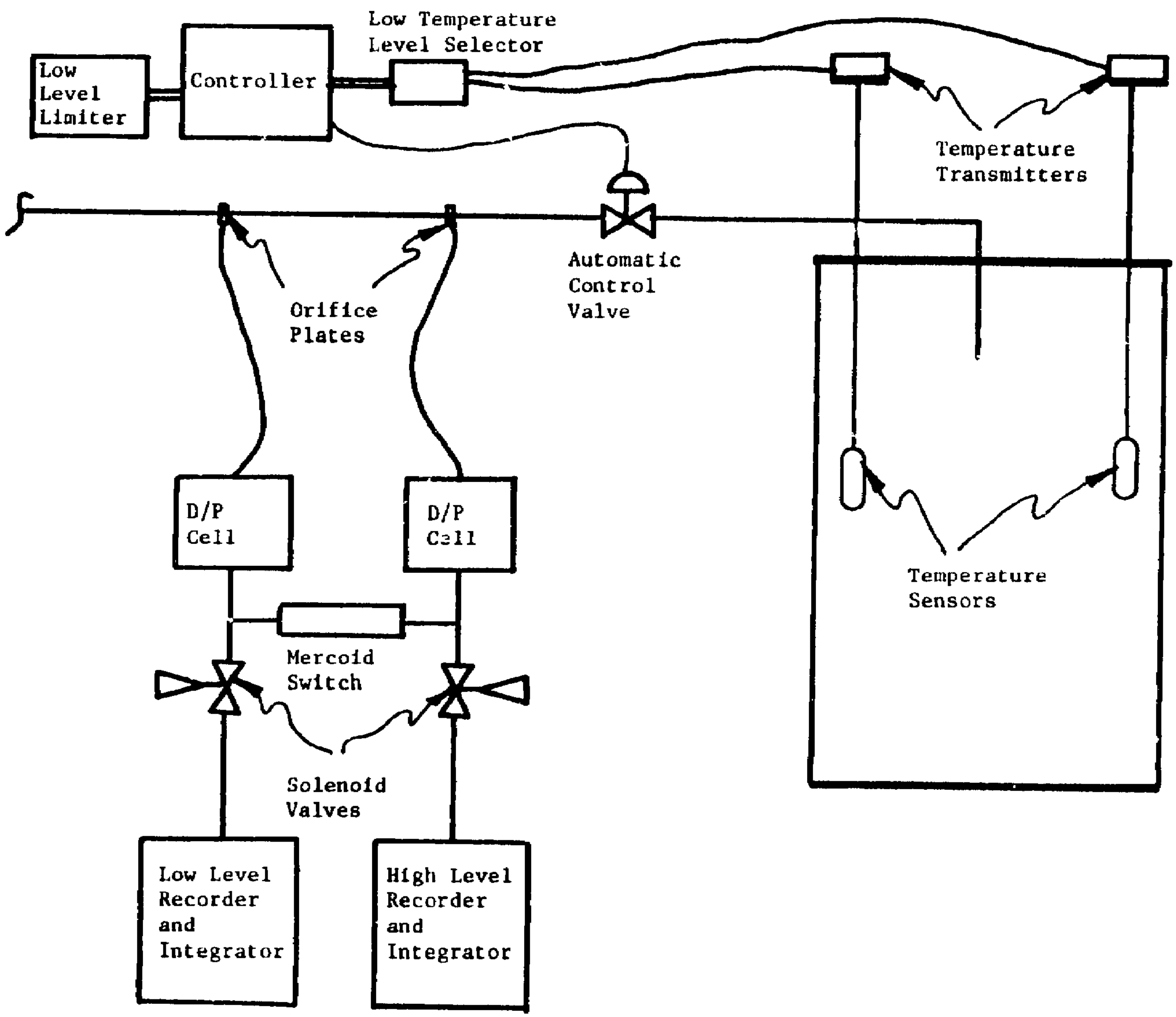

Figure 5. Steam monitoring and control of one boiling tub

APPENDIX A

ECONOMIC ANALYSIS--BOILING TUB TOP

1. Energy loss through top of uninsulated boiling tub

$Q = UA\Delta T$
$Q = (1.4)\ (\pi 9^2)\ (200-85)$
$Q = 40{,}970$ Btu/hr

Where: U = 1.4 Btu/hr/sq ft/°F for bright nickel horizontal surfaces at a 100°F temperature difference

2. Energy loss through top of insulated boiling tub

$Q = UA\Delta T$
$Q = (0.21)\ (\pi 9^2)\ (200-85)$
$Q = 6{,}145$ Btu/hr

Where: U = 0.21 Btu/hr/sq ft/°F for 2 inches of Foamglas insulation at 100°F temperature difference

3. Energy loss through two uninsulated 4 ft by 4 ft tank lids in the top of the tub

$Q = UA\Delta T$
$Q = (1.4)\ (2 \times 4 \times 4)\ (200-85)$
$Q = 5{,}152$ Btu/hr

Where: U = 1.4 Btu/hr/sq ft/°F for bright nickel horizontal surface at 100°F temperature difference

4. Energy sacrifice per boiling tub--uninsulated top (Btu/hr)

a. Uninsulated top

40,970	uninsulated top
5,152	uninsulated lids
46,122	total

b. Insulated top

6,145	insulated top
5,152	uninsulated lids
11,297	total

c. Net loss

46,122
11,297
34,825

PRECEDING PAGE BLANK-NOT FILMED

5. Steam usage--annual basis

Maximum = 8,760 hr/yr x 0.893 (% time on steam) = 7,823 hr/yr

Minimum = 8,760 hr/yr x 0.816 (% time on steam) = 7,148 hr/yr

6. Energy sacrificed per boiling tub

Maximum = 7,823 hr/yr x 34,825 Btu/yr = 27.24 x 10^7 Btu/yr

Minimum = 7,148 hr/yr x 34,825 Btu/hr = 24.89 x 10^7 Btu/yr

7. Energy sacrifice based on mobilization

Maximum = 27.24 x 10^7 Btu/yr/tub x 90 tubs = 24.52 x 10^9 Btu/yr

Minimum = 24.89 x 10^7 Btu/yr/tub x 90 tubs = 22.40 x 10^9 Btu/yr

APPENDIX B

ECONOMIC ANALYSIS--BOILING TUB SIDES

(THEORETICAL)

Energy Consumption

1. Bases

a.

Maximum NC boiling tub cycle	84 hr
Minimum NC boiling tub cycle	49 hr
Maximum time on steam during one cycle	75 hr
Minimum time on steam during one cycle	45 hr
Maximum percentage of time on steam for one cycle	89.3%
Minimum percentage of time on steam for one cycle	81.6%

b. Heat transmission coefficient, U -

(1) Carrier Handbook of Air Conditioning System Design McGraw Hill
(2) United Coatings, Spokane, Washington
(3) Pittsburg Corning Corporation, Pittsburg, Pa.

2. Calculations

a. Heat losses for an uninsulated boiling tub (side only)

$Q = UA\Delta T$
$Q = 1.7\ (\pi \times 18 \times 12)\ (200 - 85)$
$Q = 132{,}663$ Btu/hr heat loss

Where: U = 1.7 Btu/hr/sq ft/°F for bright nickel surface at a 100°F temperature difference for vertical surfaces

A = Area of surface

ΔT = Difference in temperature of tank surface and ambient air

b. Heat losses from an insulated boiling tub. Heat loss through insulated side of 18 ft diameter x 12 ft high tub.

$Q = UA\Delta T$
$Q = 0.21\ (\pi \times 18 \times 12)\ (200 - 85)$
$Q = 16{,}388$ Btu/hr lost

Where: U = 0.21 Btu/hr/sq ft/°F typical value for 2 inches of Foamglas insulation at 200°F temperature

3. Energy saved per boiling tub

Tub	Heat loss (Btu/hr)
Uninsulated	132,663
Insulated	16,388
Difference	116,275

4. Steam usage—annual basis

Maximum = 8760 hr/yr x 0.893 (% on steam) = 7823 hr/yr
Minimum = 8760 hr/yr x 0.816 (% on steam) = 7148 hr/yr

5. Energy saved per boiling tub—annual basis

Maximum = 90.96×10^7 Btu/yr/tub
Minimum = 83.11×10^7 Btu/yr/tub

6. Energy savings from facility implementation (90 tubs on 3 NC lines)

Maximum = 8.186×10^{10} Btu/yr

Minimum = 7.48×10^{10} Btu/yr

Average = 7.833×10^{10} Btu/yr

$$\text{Pounds of steam} = \frac{7.833 \times 10^{10}\ \text{Btu/yr}}{1175.6\ \text{Btu/lb steam}} = 66.6 \times 10^6\ \text{lb/yr}$$

$$\text{kg} = \frac{66.6 \times 10^6\ \text{lb/yr}}{2.2046\ \text{kg/lb}} = 30.22 \times 10^6\ \text{kg/yr}$$

DISTRIBUTION LIST

Commander
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-TSS (5)
DRDAR-LCM-S (10)
Dover, NJ 07801

Administrator
Defense Technical Information Center
ATTN: Accessions Division (12)
Cameron Station
Alexandria, VA 22314

Director
U.S. Army Materiel Systems
Analysis Activity
ATTN: DRXSY-MP
Aberdeen Proving Ground, MD 21005

Commander/Director
Chemical Systems Laboratory
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-CLJ-L
DRDAR-CLB-PA
APG, Edgewood Area, MD 21010

Director
Ballistics Research Laboratory
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-TSB-S
Aberdeen Proving Ground, MD 21005

Chief
Benet Weapons Laboratory, LCWSL
U.S. Army Armament Research and
Development Command
ATTN: DRDAR-LCB-TL
Watervliet, NY 12189

Commander
U.S. Army Armament Materiel
Readiness Command
ATTN: DRSAR-LEP-L
DRSAR-IR
DRSAR-IS
Rock Island, IL 61299

Director
Industrial Base Engineering Activity
ATTN: DRXIB-MT (2)
Rock Island, IL 61299

Commander
U.S. Army Munitions Production
Base Modernization Agency
ATTN: SARPM-PBM-EC (2)
SARPM-CE
DOVER, NJ 07801

Commander
USDRC Installations and
Services Agency
ATTN: DRCIS-RI
Rock Island, IL 61299

Commander
Radford Army Ammunition Plant
ATTN: SARRA-EN (2)
Radford, VA 24141

Commander
Badger Army Ammunition Plant
ATTN: SARBA-CE
Baraboo, WI 53913

Commander
Indiana Army Ammunition Plant
ATTN: SARIN-OR
Charlestown, IN 47111

Commander's Representative
Sunflower Army Ammunition Plant
Box 640
ATTN: SARSU-O
DeSoto, KS 66018